IN THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application.

Claim 1 (Presently Amended) A motion control system comprising:

a central controller configured to generate first and second demand control signals defining actuation motion of respective first and second actuators;

first and second ~~nodes~~ slaves in communication with said central controller, each ~~node~~ slave comprising ~~including~~,

at least a respective one of said actuators configured to implement at an actuator time an action based upon said respective demand control signal, and

a memory configured to store at least one respective propagation delay parameter related to a signal propagation delay between the central controller and each of said first and second slaves ~~the node~~;

a timing mechanism configured to establish timing at each ~~node~~ slave based on the respective propagation delay parameters ~~parameter~~, said timing mechanism configured to delay reception of a servo clock message at said first and second slaves by an amount of time corresponding to the propagation delay parameters for information passed from the central controller to the first and second slaves so that the actuator times at each of said first and second slaves ~~the nodes~~ occur simultaneously; and

a data network configured to place said first and second ~~nodes~~ slaves in communication with said central controller.

Claim 2 (Currently Amended) The system according to claim 1, wherein:

said first and second ~~nodes~~ slaves further comprise respective transducers configured to measure at a transducer time respective parameters related to motion of respective of said actuators and to generate respective feedback signals;

said central controller is configured to receive said respective feedback signals indicative of motion of said first and second actuators; and

said timing mechanism is configured to establish timing at each ~~node~~ slave based on the respective propagation delay parameter so that said transducer times occur simultaneously at the ~~nodes~~ slaves.

Claim 3 (Currently Amended) The system according to claim 1, wherein:

said first ~~node~~ slave further comprises a transducer configured to measure at a transducer time a parameter related to motion of said first actuator and to generate a first feedback signal;

said central controller is configured to receive said first feedback signal indicative of motion of said first actuator; and

said timing mechanism is configured to establish timing at said first ~~node~~ slave based on the first propagation delay parameter so that said transducer time at said first ~~node~~ slave occurs at a known time relative to a master time.

Claim 4 (Currently Amended) The system according to claim 1, wherein at least one of said first and said second ~~nodes~~ slaves further comprises a current/torque controller.

Claim 5 (Original) The system according to claim 1, wherein:

said central controller comprises a synchronization signal generator configured to generate a synchronization signal; and

said timing mechanism comprises a synchronization signal receiver configured to receive said synchronization signal.

Claim 6 (Original) The system according to claim 5, wherein said timing mechanism further comprises:

an adder configured to add each said respective propagation delay parameter to an arrival time of said synchronization signal to provide said actuator time for each actuator.

Claim 7 (Currently Amended) The system according to claim 5, wherein said ~~nodes~~ slaves each further comprise a local clock.

Claim 8 (Currently Amended) The system according to claim 7, wherein said timing mechanism further comprises:

a local clock setting mechanism configured to set each said local clock based on said synchronization signal and said respective propagation time along said data network from said central controller to each ~~node~~ slave.

Claim 9 (Original) The system according to claim 2, wherein:

said central controller comprises a synchronization signal generator configured to generate a synchronization signal; and

said timing mechanism comprises a synchronization signal receiver configured to receive said synchronization signal.

Claim 10 (Original) The system according to claim 9, wherein said timing mechanism comprises:

an adder configured to add said respective propagation delay parameter to an arrival time of said synchronization signal to provide at least one of said actuator time and said transducer time.

Claim 11 (Currently Amended) The system according to claim 10, wherein:

said ~~nodes~~ slaves each further comprise a local clock; and

said timing mechanism further comprises a local clock setting mechanism provided at each ~~node~~ slave and configured to set said local clock based on said synchronization signal and said propagation time along said data network from said central controller to each ~~node~~ slave.

Claim 12 (Currently Amended) The system according to claim 1, wherein said central controller comprises a master controller ~~and said first and second nodes comprise a first slave node and a second slave node, respectively~~.

Claim 13 (Original) The system according to claim 1, wherein said data network comprises a tree topology.

Claim 14 (Original) The system according to claim 1, wherein said data network comprises a ring topology having a forward direction and a reverse direction.

Claim 15 (Original) The system according to claim 14, wherein said ring topology comprises a full duplex ring.

Claim 16 (Original) The system according to claim 14, wherein said central controller further comprises:

a transmitter configured to transmit a signal along said ring topology; and

a receiver configured to receive an answer to said signal, said answer transmitted along said ring topology.

Claim 17 (Currently Amended) The system according to claim 16, wherein said central controller further comprises:

an identifier configured to identify a furthest ~~node~~ slave along said ring topology in a forward direction from which said answer can be received at said receiver.

Claim 18 (Currently Amended) The system according to claim 14, wherein said propagation delay parameter memory comprises:

a forward path propagation delay parameter portion configured to store a parameter related to a propagation delay from said central controller in a forward direction along said forward direction to said ~~node~~ slave; and

a reverse path propagation delay parameter portion configured to store a parameter related to a propagation delay from said central controller in a reverse direction along said reverse direction to said ~~node~~ slave.

Claim 19 (Currently Amended) The system according to claim 1, wherein said central controller is configured to autoenumerate said first and second ~~nodes~~ slaves.

Claim 20 (Currently Amended) The system according to claim 1, wherein[[:]] said central controller further comprises[[,]]:

a query message transmitter configured to transmit a query message along said data network[[,]]; and

an answer message receiver configured to receive an answer to said query message[[;]], and each of said first and second ~~nodes~~ slaves ~~each comprise,~~ comprises,

a query message receiver configured to receive said query message from said central controller, and

an answer message transmitter configured to transmit an answer message replying to a received query message, said answer message transmitted along said data network, said answer message enumerating said ~~node~~ slave.

Claim 21 (Currently Amended) The system according to claim 20, wherein said first ~~node~~ slave further comprises:

a relay configured to pass along said query message to said second ~~node~~ slave when said first ~~node~~ slave has already been enumerated.

Claim 22 (Currently Amended) The system according to claim 20, wherein said second ~~node~~ slave further comprises:

a relay configured to pass along said query message to said central controller when said second ~~node~~ slave has already been enumerated.

Claim 23 (Original) The system according to claim 20, wherein:

said query message is transmitted in a forward direction; and

said answer message is transmitted in a reverse direction.

Claim 24 (Currently Amended) The system according to claim 1, wherein said timing mechanism is disposed at each of said ~~nodes~~ slave.

Claim 25 (Currently Amended) A method of synchronizing the operations of a plurality of actuators in a system for motion control, comprising:

determining a respective propagation delay between a central controller and each actuator of said plurality of actuators; and

timing operations of each actuator based on said determined respective propagation delay for each actuator, wherein said timing operations is configured to delay reception of a servo clock message at each actuator by an amount of time corresponding to the propagation delay parameter for information passed from the central controller to each actuator so that the actuator times at each actuator occur simultaneously.

Claim 26 (Original) The method according to claim 25, wherein said timing step comprises simultaneously initiating actuation of each actuator of said plurality of actuators.

Claim 27 (Currently Amended) The method according to claim 25, further comprising: ~~a step of~~

timing operations of transducers associated with servo-actuators of said plurality of actuators based on said determined respective propagation delay.

Claim 28 (Currently Amended) The method according to claim 27, wherein said timing operations ~~of said transducers step~~ comprises simultaneously initiating measurement by said transducers.

Claim 29 (Original) The method according to claim 25, further comprising:

transmitting a synchronization signal from said central controller to said each actuator of said plurality of actuators.

Claim 30 (Original) The method according to claim 29, wherein said timing step comprises offsetting the operations of each actuator of said plurality of actuators relative to said synchronization signal based on said respective determined propagation delay for each actuator.

Claim 31 (Original) The method according to claim 25, further comprising: storing a parameter related to said respective propagation delay for each actuator of said plurality of actuators.

Claim 32 (Currently Amended) The method according to claim 25, wherein said determining step comprises:

transmitting a query signal from a central controller to a ~~node~~ slave having said actuator of said plurality of actuators at a transmission time;

receiving said query signal at said ~~node~~ slave;

replying to said query signal through an answer signal transmitted from said ~~node~~ slave to said central controller;

receiving said answer signal at said central controller at a reception time; and

determining said propagation delay based upon a difference between said transmission time and said reception time.

Claim 33 (Original) The method according to claim 25, wherein said determining step comprises:

summing predetermined relay times for preceding actuators between said central controller and a particular actuator and propagation times for preceding links between said central controller and said particular actuator to yield said propagation delay of said particular actuator.

Claim 34 (Original) The method according to claim 30, wherein said offsetting step comprises:

delaying said operations of each actuator of said plurality of actuators by said determined propagation delay.

Claim 35 (Currently Amended) A method of autoenumerating a plurality of ~~nodes~~ slaves controlled by a central controller in a system for motion control, comprising:

linking the central controller and the ~~nodes~~ slaves in a network;

determining a propagation delay between said central controller and each respective slave in said plurality of slaves by a timing mechanism configured to establish timing at each slave based on the respective propagation delay and to delay reception of a servo clock message at each slave by an amount of time corresponding to the propagation delay parameters for information passed from the central controller to each slave so that the actuator times at each of slave occur simultaneously;

transmitting a query message from the central controller ~~in~~ along said network;

receiving said query message at a ~~node~~ slave of said plurality of ~~nodes~~ slaves in said network;

transmitting an answer message to said query message along said network from said ~~node~~ slave to said central controller, said answer message enumerating said ~~node~~ slave;

receiving said answer message at said central controller;

retransmitting said query message from said central controller along said network;

relaying said retransmitted query message through said enumerated ~~node~~ slave to a further ~~node~~ slave; and

transmitting a further answer message to said query message along said network from said further ~~node~~ slave through said enumerated ~~node~~ slave to said central controller, said further answer message enumerating said further ~~node~~ slave.

Claim 36 (Original) The method according to claim 35, wherein said query message is transmitted in a first direction and said answer message is transmitted in a reverse direction.

Claim 37 (Currently Amended) The method according to claim 35, wherein said linking step comprises arranging the central controller and the ~~nodes~~ slaves in a ring network.

Claim 38 (Currently Amended) The method according to claim 37, further comprising:

repeating said steps of retransmitting said query message, relaying said query message, and transmitting a further answer message until said further ~~node~~ slave comprises a last ~~node~~ slave in said ring network;

transmitting said query message from said central controller along said ring network;

relaying said query message through each ~~node~~ slave in said plurality of ~~nodes~~ slaves; and

receiving said query message at central controller.

Claim 39 (Original) The method according to claim 35, further comprising a step of determining a propagation delay between said central controller and each node in said plurality of nodes.

Claim 40 (Currently Amended) A method of maintaining operation in the event of a fault of a system for motion control with a plurality of ~~nodes~~ slaves in a ring network controlled by a central controller, comprising:

transmitting first messages addressed to plural respective ~~nodes~~ slaves in a first direction along said ring network;

monitoring first reply messages transmitted by said plural ~~nodes~~ slaves in a second direction along said ring network in response to the transmitted first messages;

identifying, when first reply messages are not received from each ~~node~~ slave to which a first message was transmitted, a first subset of ~~nodes~~ slaves from which said first reply messages are received, and based thereon, determining a second subset of ~~nodes~~ slaves exclusive of said first subset of ~~nodes~~ slaves, from which respective first reply messages were not received;

transmitting in said second direction, when first reply messages are not received from each ~~node~~ slave to which a first message was transmitted, second messages addressed to respective ~~nodes~~ slaves in said second subset of ~~nodes~~ slaves; receiving second reply messages transmitted by respective of said ~~nodes~~ slaves of said second subset of ~~nodes~~ slaves in response to said second messages, said second reply messages traveling in said first direction along said ring network;

transmitting in said first direction third messages addressed to said first subset of ~~nodes~~ slaves; and

transmitting in said second direction fourth messages addressed to said second subset of ~~nodes~~ slaves.

Claim 41 (Original) The method according to claim 40, wherein said ring network comprises a full-duplex ring network.

Claim 42 (Currently Amended) A motion control system, comprising:

means for determining ~~a~~ respective propagation ~~delay~~ delays between a central controller and ~~each actuator of said~~ a plurality of actuators; and

means for ~~timing operations of each actuator of said plurality of actuators based on said determined respective propagation delay for each actuator~~ delaying reception of a servo clock message to stablish timing at each actuator based on each respective propagation delay parameter at each actuator so that the actuator times at each actuator occur simultaneously.

Claim 43 (Currently Amended) An autoenumerating motion control system comprising:

a network; and

a central controller and plural ~~nodes~~ slaves communicating with each other via said network; and

at least one timing mechanism, wherein said timing mechanism is configured to establish timing at each slave based on a respective propagation delay parameter for each slave and to delay reception of a servo clock message at each of said plural slaves by an amount of time corresponding to each respective propagation delay parameter for information passed from the central controller to each of said plural slaves so that the actuator times at each of said plural slaves occur simultaneously,

wherein the central controller ~~including,~~ further comprises: means for transmitting a query message from the central controller along said network, and means for receiving said answer message at said central controller[[;]], and each of said ~~nodes~~ slaves ~~each including,~~ further comprises means for receiving said query message carried by said means for linking, means for transmitting an answer message to said query message along said means for linking from said ~~node~~ slave to said central controller, said answer message enumerating said ~~node~~ slave, and means for relaying a further query message through said enumerated ~~node~~ slave to a further ~~node~~ slave and a further answer message to said query message along said

network from said further ~~node~~ slave through said enumerated ~~node~~ slave to said central controller, said further answer message enumerating said further ~~node~~ slave.

Claim 44 (Currently Amended) A system for operating a plurality of ~~nodes~~ slaves controlled by a central controller via a ring network in the event of a fault, comprising:

means for transmitting first messages addressed to plural respective ~~nodes~~ slaves in a first direction along said ring network;

means for monitoring first reply messages transmitted by said plural ~~nodes~~ slaves in a second direction along said ring network in response to the first messages transmitted by said means for transmitting first messages;

means for identifying, when first reply messages are not received from each ~~node~~ slave to which a first message was transmitted, a first subset of ~~nodes~~ slaves from which said first reply messages are received, and, based thereon, for determining a second subset of ~~nodes~~ slaves exclusive of said first subset of ~~nodes~~ slaves, from which respective first reply messages were not received;

means for transmitting in said second direction, when first reply messages are not received from each ~~node~~ slave to which a first message was transmitted, second messages addressed to respective ~~nodes~~ slaves in said second subset of ~~nodes~~ slaves; and

means for receiving second reply messages transmitted by respective of said ~~nodes~~ slaves of said second subset of ~~nodes~~ slaves in response to said second messages transmitted by said means for transmitting in said second direction, said second reply messages traveling in said first direction along said ring network.

Claim 45 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 25.

Claim 46 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by [[a]] the computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 26.

Claim 47 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 27.

Claim 48 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 28.

Claim 49 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 29.

Claim 50 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 30.

Claim 51 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 31.

Claim 52 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 32.

Claim 53 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 33.

Claim 54 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 34.

Claim 55 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 35.

Claim 56 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 36.

Claim 57 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 37.

Claim 58 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 38.

Claim 59 (Original) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system, cause the computer system to perform the method recited in claim 39.

Claim 60 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 40.

Claim 61 (Currently Amended) A computer readable medium storing instructions for execution on a computer system, which when executed by a computer system[[,]] ~~cause~~ causes the computer system to perform the method recited in claim 41.

Claim 62 (Currently Amended) A ~~node~~ slave configured to be in communication with a central controller over a data network, said ~~node~~ slave comprising:

a delay correction memory configured to store a delay correction signal related to a propagation delay between said central controller and said ~~node~~ slave over said data network; ~~and~~

an actuator configured to implement a motion or force-related effort at an actuator time based upon said stored delay correction signal; and

a timing operation mechanism configured to establish timing at the slave based on the propagation delay and to delay reception of a servo clock message at the actuator by an amount of time corresponding to the propagation delay signal for information passed between the slave and the central controller.

Claim 63 (Currently Amended) The ~~node~~ slave according to claim 62, further comprising:

a delay correction receiver configured to receive said stored delay correction signal related to said propagation delay.

Claim 64 (Currently Amended) The ~~node~~ slave according to claim 62, further comprising:

a ~~node~~ slave clock configured to maintain a ~~node~~ slave time; and

a clock setting mechanism configured to set said ~~node~~ slave time of said ~~node~~ slave clock based upon said stored delay correction signal, wherein said actuator time is based upon said set ~~node~~ slave time.

Claim 65 (Currently Amended) The ~~node~~ slave according to claim 62, wherein said ~~node~~ slave being connected in a full-duplex ring and said delay correction signal comprising a forward path delay correction signal and a reverse path delay correction signal.

Claim 66 (Currently Amended) The ~~node~~ slave according to claim 62, wherein said delay correction signal comprising a forward path delay correction signal.

Claim 67 (Currently Amended) A ~~node~~ slave configured to be in communication during operation with a central controller over a full-duplex data network, said ~~node~~ slave comprising:

a first receiver configured to receive a first signal transmitted along a first direction over said data network;

a second receiver configured to receive a second signal transmitted along a second direction over said data network; ~~and~~

an actuator configured to implement an action based one of said received first signal and said second signal; and

a timing operation mechanism configured to establish timing at the slave, based on a propagation delay parameter between the slave and the central controller, and to delay reception of a servo clock message by an amount of time corresponding to the propagation delay signal for information passed between the slave and the central controller so that an actuation time at the slave occur simultaneously.

Claim 68 (Currently Amended) The ~~node~~ slave according to claim 67, further comprising:

a first reply transmitter configured to answer said first signal in said second direction;

a second reply transmitter configured to answer said second signal in said first direction; and

a selector configured to select said first reply transmitter when said first signal is received and said second reply transmitter when said second signal is received.

Claim 69 (Currently Amended) The ~~node~~ slave according to claim 68, further comprising:

a delay correction memory configured to store a forward path delay correction signal and a reverse path delay correction signal, wherein:

said actuator is configured to implement said motion or force-related effort at an actuator time based upon a selected one of said forward path delay correction signal and said reverse path delay correction signal; and

said selector also is configured to select said forward path delay correction signal when said first signal is received and said reverse path delay correction signal when said second signal is received.